REMARKS/ARGUMENTS:

Minor changes are made to this specification. Claims 9 and 12-21 are canceled without prejudice. Claims 1, 7, and 10 are amended. New claim 22 is added. Claims 1-8, 10, 11, and 22 are pending in the application. Reexamination and reconsideration of the application, as amended, are respectfully requested.

The present invention relates to a surface acoustic wave device which comprises a surface acoustic wave element that is formed with an inter digital transducer electrode (hereinafter referred to as "IDT electrode"), a connector electrode and a periphery sealing electrode and joined to a base substrate through a solder bump component and a solder sealing component, and a method for manufacturing the same. (Applicant's specification, at p. 1, lines 9-15).

CLAIM REJECTIONS UNDER 35 U.S.C. § 103:

Claims 1-3 and 7-11 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Hori (U.S. Patent No. 6,498,422). This rejection is moot with respect to claim 9 due to the cancellation of this claim. The Applicant respectfully traverses this rejection as to claims 1-3, 7, 8, 10, and 11. Claim 1, as amended, is as follows:

> A surface acoustic wave device comprising:
>
> a surface acoustic wave element including a piezoelectric substrate which includes one principal surface formed with an inter digital transducer electrode, a connector electrode connected to the inter digital transducer electrode and a periphery sealing electrode; and
>
> a base substrate formed with an electrode for connection to the element that is connected to the connector electrode, and a periphery

sealing conductor film joined to the periphery sealing electrode; wherein the connector electrode and the electrode for connection to the element are joined together through a solder bump component, and the periphery sealing electrode and the periphery sealing conductor film are joined together through a solder sealing component between the base substrate and the surface acoustic wave element,

the solder bump component and the solder sealing component comprise a Sn-Sb based or Sn-Ag based lead-free solder containing 90% or more Sn, and

the base substrate has a thermal expansion coefficient of 9-20 ppm/°C.

Conventionally, when a heat treatment such as a solder reflow treatment is carried out, the lead component in the solder has the function to absorb stress caused by the difference in thermal expansion coefficient between the substrate and the surface acoustic wave element (Applicant's specification, at p. 2, lines 19-22).

However, the Sn-Sb based lead-free solder containing 90% or more Sn, less easily absorbs the thermal stress than solders containing lead (Applicant's specification, at p. 8, lines 6-8).

The stress that cannot be absorbed by the solder sealing component may cause strain or warpage to occur in the surface acoustic wave element and the base substrate (Applicant's specification, at p. 8, lines 14-17).

In claim 1, the base substrate has a thermal expansion coefficient of 9-20 ppm/℃. This numeric limitation is supported at p. 32, line 19-p. 34, line 24 of the Applicant's specification.

The present inventors used six kinds of substrate materials for the base substrate 2 whose thermal expansion coefficients were within the range of 7-25

ppm/℃. The material used for the solder was Sn-Ag-Cu based solder. By setting the sealing width, for example, to 200 μm, the Applicants investigated the relationship between the amount of plastic strain of the base substrate and mean time to failure. The amount of plastic strain refers to the ratio of strain at one side of the base substrate 2 to the thickness of the substrate while the base substrate 2 is joined to the surface acoustic wave element 1. The mean time to failure was obtained from the average number of occurrences of failure resulted from the repetition of a cycle -40 ℃to 125 ℃ for 30 minutes. (Applicant's specification, at p. 32, line 19-p. 33, line 6).

As a result, a graph shown in Fig. 6 was obtained. In Fig. 6, the horizontal axis represents thermal expansion coefficient of the substrate (unit: ppm/℃), the vertical axes represent mean time to failure (unit: cycle) and ratio of plastic strain (unit: %). (Applicant's specification, at p. 33, lines 7-11).

As is apparent from Fig. 6, the amount of plastic strain and the mean time to failure each have a distinct correlation with the thermal expansion coefficient of the base substrate. <u>Specifically, when the thermal expansion coefficient of the base substrate is in the range of 9-20 ppm/℃, the amount of plastic strain can be less than 2.0%, and hence the mean time to failure can be 1000 cycles or more</u>. (Applicant's specification, at p. 33, lines 12-18).

On the other hand, when the thermal expansion coefficient of the base substrate is less than 9 ppm/℃, stress caused by the difference in thermal expansion coefficient between the base substrate 2 and the surface acoustic wave element 1 increases. As a result, the amount of plastic strain becomes so great that failure occurs before the number of temperature cycles reaches 1000. (Applicant's specification, at p. 33, lines 19-25).

Alumina-ceramic substrate (7.1 ppm/℃) seemed to be a possible material for such a substrate. However, in this case, the crack generation rate in the surface acoustic wave element 1 immediately after the joining exceeds 30%. In addition, cracks are generated in the surface acoustic wave element 1 at a rate of 2-3% during 10 temperature cycles. Judging also from the strain in the base substrate and stress at the joints, this material does not reach the level of practical use. (Applicant's specification, at p. 34, lines 1-8).

When, on the contrary, the thermal expansion coefficient of the base substrate exceeds 20 ppm/℃, stress caused by the difference in thermal expansion coefficient between the base substrate 2 and the surface acoustic wave element 1 increases. As a result, the amount of plastic strain becomes so great that failure occurs before the number of temperature cycles reaches 1000. (Applicant's specification, at p. 34, lines 9-15).

Meanwhile, when the above stated range of 9-20 ppm/℃ is taken into consideration, a glass-ceramic substrate comprising alumina-ceramic powder as an inorganic filler and glass-ceramics distributed in the interfaces among the powder particles may be quoted as an example. Depending on the composition of the glass—ceramics and blending of the alumina-ceramic powder and glass-ceramics, the substrate can have a relatively freely adjusted thermal expansion coefficient. (Applicant's specification, at p. 34, lines 16-24).

By the configuration of claim 1, wherein the base substrate has a thermal expansion coefficient of 9-20 ppm/℃, the stress that could not be absorbed by the solder sealing component does not cause strain or warpage to occur in the surface acoustic wave element and the base substrate. It permits stable connection to be maintained for a long duration of time.

In view of the foregoing, claim 1 and its dependent claims 2 and 3 are patentable over Hori. Withdrawal of this rejection is thus respectfully requested.

Claim 7, as amended, is as follows:

A surface acoustic wave device comprising:

a surface acoustic wave element including a piezoelectric substrate which includes one principal surface formed with an inter digital transducer electrode, a connector electrode connected to the inter digital transducer electrode and a periphery sealing electrode; and

a base substrate which is formed with an electrode for connection to the element that is connected to the connector electrode, <u>and</u> a periphery sealing conductor film joined to the periphery sealing electrode,

wherein the connector electrode and the electrode for connection to the element are joined together through a solder bump component, and the periphery sealing electrode and the periphery sealing conductor film are joined together through a solder sealing component between the base substrate and the surface acoustic wave element,

a side surface covering resin layer is attached to cover a side surface of the surface acoustic wave element and an outer peripheral surface of the solder sealing component, wherein the side surface covering resin layer has an elastic modulus of 3.5-6 GPa at 25 °C and an elastic modulus of 0.2-0.4 GPa at 230 °C.

Claim 7, as amended, incorporates the limitation of canceled claim 9.

The material for the side surface covering resin layers 5b is a resin component with thermal reversibility, for example, an epoxy-based resin

component. For example, the side surface covering resin layers comprise an epoxy resin component, an inorganic filler, a curing agent component and a silicone elastomer component. The elastic modulus can be controlled by controlling the silicone elastomer component. The elastic modulus is 3.5—6 Gpa at 25 ℃ and 0.2-0.4 Gpa at 230 ℃. (Applicant's specification, at p. 65, lines 2-9).

Such a resin has strength necessary to protect the surface acoustic wave element 1 against impacts from the outside at ordinary temperatures such as 25 °C, and at the same time, warpage due to the contraction upon curing of the resin can be prevented. In addition, because the elastic modulus drops at the temperature, for example, 230 °C at which the solder bump component 3 and solder sealing component 4 fuse, the resin can deform following the volume expansion during the fusing of the solder bump component 3 and solder sealing component 4, thus allowing the gap between the surface of the base substrate 2 and the principal surface of the surface acoustic wave element 1 to change. As a result, short circuit failures caused by solder flow will not occur, as well as the adhesion to the surface acoustic wave element 1 can be maintained. (Applicant's specification, at p. 65, lines 10-23).

Advantages offered from the present invention are further exemplified in Tables 1 and 2 of the Applicant's specification, at pages 67 and 69, respectively.

In view of the foregoing, claim 7 and its dependent claims 8, 10, and 11 are patentable over Hori. Withdrawal of this rejection is thus respectfully requested.

ALLOWABLE SUBJECT MATTER:

The Office states, "Claims 4-6 are objected to as being dependent upon a rejected base claim, but would allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims." However, since claims 4-6 depend from claim 1, and claim 1 is believed to be patentable; claims 4-6 are believed to be patentable in their current form. Withdrawal of this objection and allowance of claims 4-6 is thus respectfully requested.

The art made of record but not relied upon by the Examiner has been considered. However, it is submitted that this art neither describes nor suggests the presently claimed invention.

In view of the foregoing, it is respectfully submitted that the application is in condition for allowance. Reexamination and reconsideration of the application, as amended, are requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California telephone number (213) 337-6700 to discuss the steps necessary for placing the application in condition for allowance.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1314.

Respectfully submitted,

HOGAN & HARTSON L.L.P.

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By: ________________

Lawrence J. McClure
Registration No. 44,228
Attorney for Applicant(s)

500 South Grand Avenue, Suite 1900
Los Angeles, California 90071
Phone: 213-337-6700
Fax: 213-337-6701